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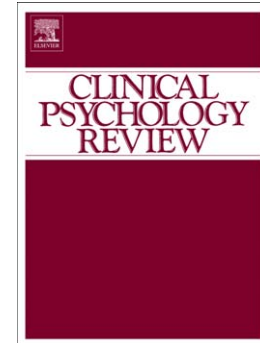
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Suzanne Ho-wai So, Nicolson Yat-fan Siu, Hau-lam Wong, Wai Chan, Philippa Anne Garety

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**'Jumping to conclusions' data-gathering bias in psychosis and other
psychiatric disorders – two meta-analyses of comparisons between
patients and healthy individuals**

Suzanne Ho-wai So^{a*}, Nicolson Yat-fan Siu^a, Hau-lam Wong^a, Wai Chan^a,
Philippa Anne Garety^b

^a *Department of Psychology, The Chinese University of Hong Kong, Hong Kong SAR.*

^b *Department of Psychology, Institute of Psychiatry, Psychology and Neuroscience, King's College London, London, United Kingdom.*

*Corresponding author at: Room 321, 3/F, Department of Psychology,
Wong Foo Yuan Building, The Chinese University of Hong Kong, Shatin,
New Territories, Hong Kong SAR. Tel: +852 3943 6211. Fax: +852
26035019.*

Email address: shwso@psy.cuhk.edu.hk (S.H. So)

Abstract

There has been an increase in attention to studying shared mechanisms underlying psychiatric disorders. The 'Jumping to conclusions' (JTC¹) bias, a tendency to make decisions with certainty based on insufficient information, has been reported in patients with psychosis, and process-based treatment protocols targeting this bias have recently been developed. This review aimed to investigate to what extent the JTC bias, measured by various tasks, is associated with psychotic disorders and other psychiatric disorders using a meta-analytic approach.

We examined 6864 articles published between 1990-2015, and meta-analysed 46 studies. The first meta-analysis included 40 effect sizes comparing patients with schizophrenia spectrum or other psychotic disorders and healthy controls. There was a hastier data-gathering style in patients with psychosis than healthy individuals, with a moderate aggregated effect size. The second meta-analysis included 18 effect sizes comparing patients with non-psychotic disorders and healthy controls. There was marked heterogeneity in effect sizes and evidence for publication bias. After removal of outliers, the aggregated effect size for JTC was not statistically significant. A planned subgroup analysis showed no significant effect of JTC in depression. Other diagnostic subgroups yielded small non-significant results. Therefore, our findings do not support the suggestion that JTC is a transdiagnostic phenomenon beyond psychosis.

Keywords: reasoning; jumping to conclusions; transdiagnostic; cognitive bias; psychosis; delusions

¹ JTC = Jumping to conclusions

Introduction

There have been recent calls for an approach to study, conceptualise, and treat psychiatric disorders according to the similarities and differences of their underlying mechanisms (Barlow, Allen & Choate, 2004; Mansell, Harvey, Watkins & Shafran, 2008; Wigman et al., 2015). While a transdiagnostic approach to research and intervention has shown promise in advancing our understanding of psychopathology, researchers have emphasised the importance of empirical work that investigates (i) the extent to which a maladaptive phenomenon is specific to one disorder, one symptom within a disorder, or relevant across disorders; (ii) how the phenomenon relates to the phenotypical features of the disorders; and (iii) whether the phenomenon is a consequence or antecedent of the disorders (Eaton, Rodrigues-Seijas, Carragher, & Krueger, 2015; Goschke, 2014; McManus, Shafran, & Cooper, 2010).

Dysfunctions in decision-making are cardinal features in a range of mental disorders, including psychosis, addiction, eating disorders, depression, and anxiety disorders (Wittchen et al., 2011). Individuals with substance dependence, attention-deficit hyperactivity disorder, or other impulse-control problems have been found to be impulsive and unreflective in their judgements and decisions. Ershe et al. (2012) and Garavan and Hester (2007) proposed that these individuals tend to use a Type 1 (as opposed to a Type 2) thinking style more often. According to the dual-process theory of reasoning, the Type 1 system refers to associative, effortless, heuristic, and suboptimal processes (Evans, 1989, 2006; Sloman, 1996). These processes are assumed to be experiential and foster intuitive judgments (Epstein, 1994; Hammond, 1996). The Type 2 system refers to the rule-based, conscious, effortful, analytic,

and controlled processes of reasoning (Hammond, 1996; Sloman, 1996). These processes are assumed to be rational and characterize deliberative judgments (Epstein, 1994). There remain debates about the terminology of the two systems and whether the two systems are distinct and competitive (Kruglanski & Gigerenzer, 2011).

Kahneman and Frederick (2005) and Evans (2008) suggested that the fast Type 1 reasoning processes cue default intuitive judgements, which are endorsed by the analytic Type 2 system. When the Type 2 high-effort deliberative thinking intervenes, the biased and heuristic-based response can be inhibited and replaced with reflective reasoning. Applying this theory to paranoia, Freeman, Evans, & Lister (2012) and Freeman, Lister, & Evans (2014) hypothesised that “paranoid fears may be partly driven by rapid gut feeling intuitions that are not then kept in check by the application of effortful logical reasoning” (Freeman et al., 2014, p. 454). There is preliminary evidence supporting the link between sub-clinical paranoid ideas and reduced Type 2 thinking (Freeman et al., 2012), and that some evidence may be perceived as hypersalient by patients with delusions, leading to faster and heuristic-based decisions (Speechley, Murray, McKay, Munz, & Ngan, 2010). Garety et al. (2015) argued that reasoning training for delusions may take effect by helping patients to inhibit Type 1 reasoning and to engage more in Type 2 reasoning.

The Jumping to conclusions bias (JTC) is a tendency to make decisions with certainty based on insufficient information. Reviews have suggested that JTC is particularly associated with delusions (Fine, Gardner, Craigie, & Gold, 2007; Garety & Freeman, 2013; So, Garety, Peters, & Kapur, 2010). Garety and Freeman (2013) posited that JTC, together with other processes including

limited belief flexibility and anxiety, contributes to delusion formation and maintenance, as individuals rapidly appraise anomalous or ambiguous stimuli and reach a delusional conclusion based on limited evidence.

The literature in the area of JTC and delusions has expanded over the last two decades, with the development of newer experimental paradigms to assess the JTC bias, inclusion of both clinical and non-clinical groups along the continuum of delusions, and investigations of more specific associations between JTC and aspects of delusional experience (see review by Dudley, Cavanagh, Daley, & Smith, 2014). Importantly, there is evidence that a greater tendency to JTC is predictive of less improvement over time in delusions (Dudley et al, 2013; Menon, Mizrahi, & Kapur, 2008; Sanford, Lecomte, Leclerc, Wykes, & Woodward, 2013; So, Peters, Swendsen, Garety, & Kapur, 2014). These findings have led to the recent development and testing of process-based treatment protocols targeting JTC and delusions (see review by Moritz et al., 2014; see also Garety et al, 2015; Waller et al, 2015; So et al., 2015).

While JTC has mostly been reported in relation to psychosis, it has been less examined in other mental disorders. For example, a tendency to come to a hasty decision under ambiguity may also be prominent in individuals with anxiety and a need for closure (Bensi & Giusberti, 2007; Broome et al., 2007; Freeman et al., 2006), or individuals with deficits in working memory and executive functioning (Lunt et al., 2012). On the other hand, patients with obsessive-compulsive disorder, characterized by intolerance of uncertainty and ruminations, may be more conservative in reaching a decision (Fear & Healy, 1997; Jacoby, Abramowitz, Buck, & Fabricant, 2014). The general aim of this study, therefore, is to extend the current literature by addressing the question to

what extent JTC is associated with psychosis and with other mental disorders, using a meta-analytic approach.

Measures of the JTC data-gathering bias

The beads task (Phillips & Edwards, 1966) is an experimental task designed to examine individuals' reasoning style under ambiguous conditions. In the original 'draws to decision' (DTD) paradigm of the beads task, used in Garety, Hemsley, and Wessely (1991) and Huq, Garety, and Hemsley (1988), individuals are presented with two jars each containing 100 coloured beads. There are 85 beads of one colour (e.g. black) and 15 beads of another colour (e.g. yellow) in one jar, whereas the other jar contains beads in opposite proportions (i.e. 15 black and 85 yellow). The participant is told that one of the jars is selected at random and beads will be drawn from the selected jar. Each time one bead will be drawn, and then the bead will be returned to the jar. Therefore, the proportion of coloured beads in the jar will not change, maintaining the ambiguity of the task condition. Participants can decide how many beads they would like to see (up to 20) before they make the decision with certainty from which jar the beads are drawn. The task is terminated once a decision has been made. Requesting a very small number of beads before making a decision (or draws to decision, DTD) is considered as an indicator of a JTC data-gathering style.

Garety et al. (2005) suggested dichotomizing the DTD measure into presence or absence of an extreme JTC bias, with two beads or fewer classified as an extreme JTC response. This method of assessing JTC has been used in numerous studies (e.g. Garety et al., 1991, 2005; So, Freeman, & Garety, 2008; Startup, Freeman, & Garety, 2008). Other studies have taken an even more

stringent criterion, with decisions after one bead considered as an extreme JTC response (e.g. Balzan, Delfabbro, Galletly, & Woodward, 2012; Moritz & Woodward, 2005; Moritz, Woodward, & Lambert, 2007).

In a harder version of the beads task, the colour ratio is changed from 85:15 to 60:40 (Dudley, John, Young, & Over, 1997a). Both versions have been used in numerous studies because while the simple 85:15 version is suitable for assessing patients in an acute psychotic episode or with poor concentration, the more difficult version is more sensitive in discriminating differences between groups with attenuated biases, including 'at risk' groups and non-clinical individuals (Lincoln, Lange, Burau, Exner, & Moritz, 2010; So et al., 2008, 2012; Startup et al., 2008; Warman, Lysaker, Martin, Davis, & Haudenschild, 2007; White & Mansell, 2009; Young & Bentall, 1997). Researchers have also examined the effect of task demands by increasing number of jars to 3 (Broome et al., 2007) or 4 (Moritz et al., 2007; White & Mansell, 2009). However, there is no unequivocal evidence that data-gathering style varies with number of jars, and the 2-jar versions of the beads task remain the most commonly used measures of JTC. Other studies modified the task by leaving the drawn beads visible to the participants during the trial, so as to reduce the demand on working memory (Dudley et al., 1997a; Garety et al., 2005).

Apart from the classic beads task, which has been criticized as abstract and lacking ecological validity (Lincoln, Salzmann, Ziegler, & Westermann, 2011), researchers have developed other variants of the task using more naturalistic materials. These variants include fishes from two lakes (Speechley et al., 2010; Woodward, Munz, LeClerc, & Lecomte, 2009), children from two schools (Dudley, John, Young, & Over, 1997b; Menon, Pomarol-Clotet, McKenna,

& McCarthy, 2006), and self-referent or emotionally salient materials, such as words from two surveys about a liked or disliked person (Young & Bentall, 1997), a person very much like the participant (Dudley et al., 1997b; Menon et al., 2006; Warman & Martin, 2006) or about the participant him/herself (Warman et al., 2007).

To examine other aspects of decision making, e.g. confidence in decisions, variations have been made to the beads task, not only with the test materials, but the instructions. In the ‘probabilistic estimation’ condition, the number of beads presented is predetermined by the experimenter and each participant is presented with the same number of beads. Participants are asked, after each bead drawn, how certain they are that the beads are being drawn from a particular jar. Unlike the classic DTD condition, participants are not required to decide on the jar from which the beads are drawn. Instead, the variables of interest in this paradigm are the number of draws required to reach a high level of certainty, and the mean level of certainty on the early trials of the task (Dudley et al., 1997a; Joyce, Averbeck, Frith, & Shergill, 2013; Moritz & Woodward, 2005, 2006; Peters & Garety, 2006). The ‘probabilistic estimation’ condition has also been applied to other JTC task paradigms – such as the ‘Who Wants to Be a Millionaire’ paradigm, naming of paintings task, and the Picture to Decision task – where the authors were interested in the level of subjective probability required for a decision to be made (Moritz, Woodward, & Hausmann, 2006; Moritz et al., 2009; Rubio et al., 2011). Other researchers have examined how participants shift their probability judgements or certainty as more information is presented successively, so as to examine how participants respond to information that does not support their original hypothesis and whether they

'jump to new conclusions' (Dudley et al., 1997a; Fear & Healy, 1997; Garety et al., 1991; Peters & Garety, 2006). Error rates have been a measure of interest in other studies (e.g. Balzan et al., 2012; Jolley et al., 2014; Lincoln et al., 2010; Peters, Thornton, Siksou, Linney, & MacCabe, 2008; Young & Bentall, 1997).

In summary, decision-making under conditions of uncertainty has been assessed using a range of probability-based task paradigms with varying task materials, probability ratios, and instructions. Key measures of the decision-making performance include DTD, presence or absence of JTC bias (defined by $DTD < 1$ or 2), probability estimates, subjective confidence in decisions, and accuracy of decisions. Together, they provide a range of methods for evaluating how individuals make decisions and report certainty in their decisions in ambiguous situations.

Further research has tried to elucidate the underlying mechanisms of the JTC phenomenon rather than measuring the JTC bias directly. A range of other experimental tasks have been used to tap into specific subcomponents or stages of decision making, including estimation of probability, data gathering, and generation and testing of hypotheses (John & Dodgson, 1994; Linney, Peters, & Ayton, 1998; Merrin, Kinderman, & Bentall, 2007; Moritz et al., 2009; Peters et al., 2008; Rubio et al., 2011; Ziegler, Rief, Werner, Mehl, & Lincoln, 2008). Since the present paper concerns the JTC bias and its links with psychopathology, we focused on studies that measured JTC directly and not on the subcomponents of the decision making process.

The phenomenon of JTC in psychosis and delusions was first meta-analysed by Fine et al. (2007), who concluded that DTD was reliably associated with the presence of delusions. Fine et al. (2007) reported a large effect size for

DTD between patients with delusions and healthy controls, and a reduced effect size between patients with delusions and psychiatric controls (non-psychotic disorders). However, there was no direct comparison between people with non-psychotic disorders and healthy individuals. In addition, only 22 clinical and nonclinical samples, mostly with small sample sizes, were included. More importantly, they included studies regardless of their methodological quality and combined non-independent effects (using 47 effect sizes from 22 samples) (Ross, McKay, Coltheart, & Langdon, 2015; Taylor, Hutton, & Dudley, 2014).

In a recent meta-analysis, examining the association between JTC and delusional ideation along the continuum of delusions, Ross et al. (2015) found a significant negative association between data gathering and delusional ideation (measured by Peters et al. Delusions Inventory; PDI, Peters, Joseph, & Garety, 1999). Rather than aggregating reported effect sizes, Ross et al. (2015) acquired and analysed raw data from the studies, allowing a consistent use of screening criteria and statistical tests. Out of the 38 samples included, 23 were non-clinical samples. A subgroup analysis revealed that the negative association between data gathering and delusional ideation was significant in the nonclinical subgroup, but not in the clinical subgroups, which were of much smaller sample sizes. This study advanced our understanding of the association between JTC and delusional ideation in the nonclinical populations. However, the use of PDI (which is not a measure of delusions typical in clinical studies) as the only measure of delusional ideation in this meta-analysis seriously restricted the number of studies that included people with current psychotic symptoms, excluding a number of otherwise eligible studies, and led to very small numbers of clinical studies. According to Borenstein, Hedges, Higgins, and Rothstein

(2009), estimates of subgroup effect size are likely to be imprecise for subgroups of five or fewer studies (Borenstein et al., 2009, p. 163). In addition, Ross et al. (2015) included studies that used the 2-jar draws to decision version of the beads task only. Although this criterion rendered task performance directly comparable across studies, many studies that used variants of the beads task were excluded from the meta-analysis. Therefore, although this meta-analysis has provided insight into JTC and delusional thinking in non-clinical populations, its selection criteria have restricted its value for investigating clinical groups.

Objectives

The main aim of this paper was to ascertain the extent to which people with psychosis or with other non-psychotic psychiatric disorders demonstrate reduced data gathering (measured by both DTD and the JTC bias) compared to healthy controls. The first meta-analysis compared patients with psychotic disorders and healthy controls, followed by subgroup comparisons based on diagnosis and presence of delusions. The second meta-analysis compared patients with other non-psychotic psychiatric conditions and healthy controls, followed by subgroup comparisons based on the specific diagnosis.

Methods

We followed the PRISMA guidelines for reporting of this meta-analytic study (Liberati et al., 2009; Moher et al., 2009).

Eligibility criteria

Types of participants

We included studies testing for a JTC bias in adult clinical participants with a range of psychiatric disorders and symptoms. The first meta-analysis

included patients with schizophrenia spectrum or other psychotic disorders, or defined by the presence of delusions, whereas the second meta-analysis included patients with any other non-psychotic psychiatric diagnoses (on the DSM or ICD system). No treatment restriction was imposed.

Types of studies

We only included studies that compared a data-gathering bias between a clinical group and a healthy control group. A range of study designs were included: cross-sectional case-control comparisons, prospective designs where the relationship between psychosis/delusions/disorder and JTC was examined over time (in which case only the baseline data comparing groups were included), and experimental designs whereby JTC bias was experimentally manipulated (in which case only the pre-manipulation data were included). Only studies that were published in English, with full-text available, were included.

Types of measures

We included studies that measured data-gathering using the beads task, the fish task, or a word/survey task. Conceptual variants of these three tasks were included, i.e. versions with different levels of difficulty. Studies that reported draws to decision (DTD) and/or proportion of individuals exhibiting the JTC bias (based on a pre-determined cutoff score according to DTD) were included.

Excluded studies

Exclusion criteria were as follows: (i) studies with mixed clinical samples with unclear reports of diagnoses; (ii) studies with insufficient data for calculating effect sizes; (iii) case studies, commentaries, review papers, editorial letters, dissertations and abstracts.

Identification of studies

A comprehensive literature search was performed on the electronic databases PubMed, Medline and PsycInfo using the following key terms: ‘jump* to conclusion*’, ‘JTC’, ‘reasoning bias*’, ‘data gathering’, ‘liberal acceptance’, ‘bead* task*’, ‘fish* task*’, ‘survey task*’, and ‘word task*’. In order to broaden the search criteria, we did not combine these terms with terms specifying any psychiatric diagnosis or symptom. The search was limited to publications during the period of 1990 – 31 May 2015.

A secondary search was then performed using the following strategies. Additional studies were manually searched from the reference lists of the identified papers, as well as relevant review and meta-analytic papers (Fine et al., 2007; Garety & Freeman, 2013; Ross et al., 2015; Taylor et al., 2014). To further identify any studies that potentially slipped through the above search procedure, we emailed authors of the articles included in the primary search for any recently published studies. We also posted a question requesting for JTC data on ResearchGate, a networking website with more than 4.5 million researchers worldwide signed up (Van Noorden, 2014).

The procedures for study identification and selection are detailed in Figure A.

[Insert Fig. A about here]

Study selection

The titles and abstracts of all eligible studies were first screened by NYS and a research assistant to determine their relevance to this study. Studies that were screened to be irrelevant to the topic of the current meta-analyses were discarded. Full texts of the remaining articles were reviewed thoroughly to

determine if they met the inclusion and exclusion criteria. Both NYS and SHS independently reviewed the full texts to evaluate their eligibility for inclusion, followed by checking by HW and a research assistant. Disagreements between reviewers were resolved by consensus.

Data extraction

Data were independently extracted by HW and SHS, followed by two arbitrators who checked the data. Inconsistencies were resolved by consensus among the reviewers. Data extracted included the following variables: recruitment criteria, clinical diagnosis, sample size, details of JTC task, measure of JTC (DTD or proportion of participants displaying JTC bias), and test statistics.

Data synthesis and analysis

This study adopted a meta-analytic approach detailed in Borenstein et al. (2009). Hedges' g was calculated for effect sizes in studies comparing DTD between groups, whereas odds ratios (OR's) were calculated for effect sizes in studies comparing proportions of individuals exhibiting the JTC bias between groups. OR's were then converted into Hedges' g via Cohen's d (formula from Borenstein et al., 2009). During the conversion, care was taken to ensure that the direction of effect sizes was consistent between DTD and JTC bias (i.e. a smaller number of draws representing a hastier data-gathering style). For studies that reported both DTD and the JTC bias, standardised effect sizes were calculated for DTD only.

There is little evidence to date that variants of beads task (with different task materials or number of trials) yield different task performance (Dudley et al, 2014; Fine et al., 2007). Earlier factor analyses have shown that performance on the beads task (both easy and difficult versions) formed the same factor with

performance on the word/survey task (So et al., 2012) and the fish task (Chu, Sun, Andreou & So, 2015). Although there is evidence that data gathering is hastier in less ambiguous conditions (i.e. a large ratio contrast, e.g. 85:15) than more ambiguous conditions (i.e. a small ratio contrast, e.g. 60:40), this has been consistently found to apply to both patients and controls, reflecting the fact that participants take account of the task demands (e.g. Dudley et al, 1997, 2014). Therefore, for studies that used more than one version of the same data-gathering task (e.g. ratios of 85:15, 60:40 and 90:10) or more than one data-gathering task (e.g. beads task and word/survey task), we computed an average effect size across the measures.

Data collection process

We developed a data extraction spreadsheet using Microsoft Excel (2008), pilot-tested it on five randomly selected studies, and refined it accordingly. Data were extracted from included studies by NYS, checked by SHS, WC and two research assistants. Disagreements were resolved by discussion between two review authors. We contacted the authors of 11 included studies for exact data. All replied, and hence we managed to include actual test statistics (mean, *SD*, *r*, and *OR*) for all included studies in the meta-analyses. In order to avoid double counting, we juxtaposed author names, comparison groups and sample sizes among the selected studies. Authors were contacted if duplication of data was suspected.

Data items

Data were extracted from each included study on the following:

- 1) characteristics of the study (year of publication, authors, and country)

- 2) characteristics of study participants (age, psychiatric diagnosis, method of diagnosis, and inclusion and exclusion criteria)
- 3) study design (cross-sectional or repeated-measures, whether it was an intervention trial)
- 4) type of symptom measures (including psychosis, delusions, depression, anxiety, obsessions and compulsions)
- 5) type of data-gathering measures (JTC task paradigms and measures)

Risk of bias in individual studies

To evaluate and minimise the influence of data selection on the present meta-analysis, we modified and adapted the key quality criteria used by the Agency for Healthcare Research and Quality (AHRQ, 2014) and the Cochrane Handbook on risk of bias (Higgins, Thompson, Deeks, & Altman, 2003; Sterne et al., 2014). The present design-specific criteria included: (i) selection bias; (ii) performance bias; (iii) detection bias; (iv) attrition bias; and (v) reporting bias. The way these sources of bias were operationalised in this study are detailed in Appendix B. Risk of bias of the studies was evaluated by SHS and HW independently, and differences were resolved by consensus between the raters.

Summary measures

Meta-analysis was conducted using Comprehensive Meta-Analysis, Version 3.3.070 (CMA; Borenstein, Hedges, Higgins, & Rothstein, 2014). Effect sizes were computed using means, standard deviations and odds ratios where available. We computed Hedges' g , its 95% confidence interval, and the associated z and p values.

Planned methods of analysis

Assuming that the studies come from a population of studies with varied effect sizes, a random-effects model was calculated within each meta-analysis. The presence of statistical heterogeneity was then formally assessed using the Q -test and quantified by the T^2 and I^2 indices, according to the Sidik-Jonkman method (Borenstein et al., 2009). A statistically significant Q value indicates true heterogeneity in effect sizes beyond random error, whereas I^2 estimates the proportion of total variation that is due to true heterogeneity (Borenstein et al., 2009). I^2 values of 0%, 25%, 50%, and 75% signify no, low, moderate, and high heterogeneity respectively (Higgins et al., 2003).

Risk of bias across studies

We assessed the possibility of publication bias in four ways. Firstly, we constructed and visually inspected the funnel plot including each study's standard error against its effect size (Light & Pillemer, 1984). Secondly, we conducted Begg and Mazumdar rank correlation test and Egger's test of the intercept, which examine whether effect size is associated with result precision, which in turn is affected by factors such as sample size and standard error. Lastly, we computed the fail-safe N (Rosenthal, 1993).

Additional analysis

To examine effect sizes in different diagnoses, we conducted subgroup analyses testing the diagnostic variables in the two meta-analyses respectively. In Study 1 (psychotic disorder vs. controls), effect sizes were evaluated for studies that included patients with schizophrenia spectrum disorders only, and studies that included patients with delusions only. In Study 2 (non-psychotic disorder vs. controls), effect sizes were evaluated for depression studies, and

explored for smaller diagnostic subgroups (anxiety disorders and obsessive-compulsive disorder).

Results

As shown in Figure A, a total of 6864 titles and abstracts were examined. 4234 were rejected at title and abstract, and a further 2584 were rejected after the full text was reviewed. A final set of 46 studies was analysed.

Study 1

Study selection

The first meta-analysis included 39 studies. Three studies included more than one psychotic group (e.g. patients with and without delusions, or patients with different psychotic disorders), and a healthy control group. Since these studies included multiple psychotic groups and one healthy group, we chose not to include effect sizes of each of the psychotic groups as independent comparisons to the healthy group. Instead, we included the effect size of one psychotic group only (i.e. psychotic disorder with delusions) for these studies. Bentall et al. (2009) compared two delusions groups (aged ≥ 65 years and < 65 years respectively) with two healthy control groups (aged ≥ 65 years and < 65 years respectively). Since the two pairs of comparisons were independent, the two respective effect sizes were entered in the meta-analysis. Therefore, a total of 40 effect sizes from the 39 studies were entered in this meta-analysis.

Characteristics of included studies

This meta-analysis included 35 case-control observational studies and 4 experimental studies with a total of 2411 participants (1150 patients and 1261

controls). Characteristics of the included studies in this meta-analysis are found in Appendix A.

The majority of the studies ($n = 36$) that met our inclusion criteria were of adult patients (18 years or older), with a psychiatric diagnosis of schizophrenia, schizophrenia spectrum disorder, or delusional disorder. Other studies ($n = 3$) included patients with delusions regardless of psychiatric diagnoses. Most studies ($n = 29$) excluded patients with alcohol or substance dependence and those with intellectual or brain impairment. The included studies' healthy controls had an absence of current or past history of mental illness, no contact with mental health services, no head or brain injury/learning disabilities and no substance abuse. Four studies additionally excluded healthy controls with familial history of any psychiatric disorder or any psychotic disorder. Most studies ($n = 32$) did not assess delusion-proneness of the control individuals. In studies where control individuals were sub-divided according to delusion-proneness ($n = 7$), only the non-delusion/psychosis-prone group was included in analysis.

Risk of bias within studies

The design and sampling characteristics of each of the selected studies, as well as their risk of bias ratings, are shown in Appendix A. In terms of selection bias (see Appendix B for detailed descriptions), most studies ($n = 36$) ascertained patients' diagnoses using a comprehensive diagnostic interview, whereas one study used a screening assessment, and two were based on casenotes. For healthy controls, 19 studies included a comprehensive diagnostic interview to ensure participants were free from psychiatric disorders (e.g. SCID, SCAN, MINI), six used a screening assessment and 14 did not include a

diagnostic/screening procedure. Most studies included groups matched on most demographic variables, or controlled for the unmatched variables in their outcome analyses. Four studies lacked both psychiatric screening for healthy individuals and statistically controlling for unmatched variables. These studies were rated 'Fair' on selection bias.

The performance bias rating was 'good' for all selected studies. All studies provided detailed description of the data-gathering tasks used, namely the beads task ($n = 26$), fish task ($n = 4$), and word/survey task ($n = 2$). Seven studies used more than one data-gathering task, in which case effect sizes across tasks were combined. Fifteen studies used tasks of an easier stimulus ratio (e.g. 90:10, 85:15, or 80:20), nine studies used tasks of a harder stimulus ratio (e.g. 60:40, 50:50), and 15 studies used tasks of more than one stimulus ratio. Most studies asked participants to complete one to two trials of the data gathering task(s) ($n = 20$), whereas 14 required participants to complete more than two trials (3 to 20). In these studies, we reported the DTD at the point where participants came to a decision. Data gathering was measured by number of draws to decision (DTD) ($n = 15$), presence/absence of JTC bias ($n = 2$), or both ($n = 22$). Among studies that reported a presence/absence of JTC bias, most studies defined extreme JTC bias by $DTD \leq 2$, whereas 3 defined it by $DTD = 1$. Two studies received "?" rating on detection bias, as no information was available as to whether JTC task was computerised or manualised.

For attrition bias, 15 studies reported missing or excluded data for the following reasons: inaccurate comprehension of JTC task, incomplete data, outliers and subjects not fulfilling inclusion criteria. All except four studies

explicitly described how missing values were handled. All studies received “good” ratings on reporting bias.

Syntheses of results

Figure B shows summary data and a forest plot for the random-effects meta-analysis of studies that compared data gathering between patients with a psychotic disorder and healthy controls. Effect sizes were calculated based on DTD in 34 studies and based on presence/absence of JTC bias in 5 studies. Effect sizes (g) for the DTD measure range from -1.682 to 0.615 and effect sizes (g) for the JTC measure range from -1.490 to -0.605 (OR's ranging from 3.062 to 15.583).

This analysis showed a combined effect size (Hedges' g) of -0.601 (95%CI: -0.773 to -0.428, $p < .001$), indicating a hastier decision-making style in patients than controls. Heterogeneity was significant amongst these studies, at a high level ($Q(39) = 176.462$, $p < .001$, $I^2 = 77.899\%$).

[Insert Fig. B about here]

Risk of bias across studies

The funnel plot is shown in Figure C. There was no significant association between effect size and result precision on Begg and Mazumdar rank correlation test ($Tau = 0.041$, $z = 0.373$, one-tailed $p = .355$) or Egger's test ($b_0 = 1.672$, $SE = 1.212$, $t = 1.379$, one-tailed $p = .088$), suggesting no publication bias. Fail-safe N test revealed that it would take 2209 additional studies with zero effect size to increase the p value for the meta-analysis to above 0.05, indicating a robust effect size.

[Insert Fig. C about here]

Planned subgroup analysis

For the first subgroup analysis, we selected the studies that included patients with *schizophrenia spectrum disorder* only ($n = 34$; see Figure D.1). This set of studies included patients who might or might not have delusions. Assuming a random effects model, there was a significant negative effect size ($g = -0.618$, 95%CI: -0.817 to -0.419, $p < .001$), indicating a hastier decision-making style in patients with schizophrenia spectrum disorder than controls.

For the second subgroup analysis, we selected the studies that included patients with *delusions* only ($n = 22$; see Figure D.2). This set of studies included patients who had a diagnosis of schizophrenia or other psychotic disorder, and where in addition the current presence of delusions was confirmed. Assuming a random effects model, there was a significant negative effect size ($g = -0.615$, 95%CI: -0.857 to -0.373, $p < .001$), indicating a hastier decision-making style in patients with delusions than controls.

[Insert Fig. D about here]

Study 2 Results

Study selection

As shown in Figure A, 17 studies (including 18 effect sizes) were included in the second meta-analysis, comparing patients with diagnoses of non-psychotic disorders and healthy controls, including a total of 885 participants (446 patients and 439 controls). Bentall et al. (2009) compared two depression groups (aged ≥ 65 years and < 65 years respectively) with two healthy control groups (aged ≥ 65 years and < 65 years respectively). Since the two pairs of comparisons were independent, the two respective effect sizes were entered in the meta-analysis.

Characteristics of included studies

Characteristics of the included studies in this meta-analysis are found in Appendix A. Sixteen studies adopted a case-control observational design, and one was an experimental study.

The majority of the studies which met our inclusion criteria were of adult patients (18 years or older), with a psychiatric diagnosis of major depressive disorder ($n = 5$), anxiety disorders ($n = 3$) or obsessive compulsive disorder (OCD; $n = 3$). Other studies included patients with unmedicated ADHD ($n = 1$), functional movement disorder ($n = 1$), anorexia nervosa ($n = 2$), Asperger's syndrome ($n = 1$) and pathological gambling ($n = 1$). Most studies excluded patients with alcohol or substance dependence, learning disabilities and brain damage. The majority of the included studies ($n = 12$) included healthy controls with no current or past history of psychiatric disorders. One study excluded healthy controls with familial history of schizophrenia in a first degree relative.

Risk of bias within studies

As shown in Appendix A, patients were assessed with a comprehensive diagnostic interview ($n = 16$) or a screening assessment ($n = 1$). Healthy controls were formally assessed using a comprehensive diagnostic interview ($n = 6$) and screening instrument ($n = 3$). Eight studies did not include a diagnostic/screening procedure for non-clinical individuals. Most studies included groups matched on most demographic variables, or controlled for the unmatched variables in their outcome analyses. One study lacked psychiatric screening for healthy individuals *and* did not control for unmatched variables, and was rated 'Fair' on selection bias.

All studies provided a detailed description of the data-gathering tasks used, namely the beads task ($n = 10$), fish task ($n = 1$), and word/survey task ($n =$

2). Four studies used more than one data-gathering task, in which case effect sizes across tasks were combined. Four studies used tasks of an easier stimulus ratio (e.g. 90:10, 85:15, or 80:20), 5 studies used tasks of a harder stimulus ratio (e.g. 60:40, 50:50), and 8 studies used tasks of more than one stimulus ratio. Most studies asked participants to complete one to two trials of the data gathering task(s) ($n = 8$), whereas 7 required participants to complete more than two trials (3 to 30). In these studies, we reported the DTD at the point where participants came to a decision. Data gathering was measured by number of draws to decision (DTD) ($n = 9$), presence/absence of JTC bias ($n = 0$), or both ($n = 8$). Among studies that reported a presence/absence of JTC bias, most studies defined extreme JTC bias by $DTD \leq 2$, whereas two defined it by $DTD = 1$.

For attrition bias, seven studies reported missing or excluded data for the following reasons: inaccurate comprehension of JTC task, incomplete data, outliers and subjects not fulfilling inclusion criteria. All studies received good ratings on attrition, reporting and performance biases. No study received a poor rating on any domain, and hence we did not exclude any study based on risk of bias.

Syntheses of results

Figure E shows summary data and a forest plot for the random-effects meta-analysis of studies that compared data gathering between patients with non-psychotic disorders and healthy controls. All effect sizes were calculated based on DTD. Effect sizes (g) range from -2.679 to 0.405.

This analysis showed a combined effect size (Hedges' g) of -0.316 (95%CI: -0.589 to -0.042, $p = .024$), indicating a hastier decision-making style in patients

than controls. Heterogeneity was significant amongst these studies, at a high level ($Q(17) = 64.834, p < .001, I^2 = 73.779\%$).

[Insert Fig. E about here]

Risk of bias across studies

The funnel plot, as shown in Figure F, is obviously asymmetric. Egger's test and Begg and Mazumdar rank correlation test revealed a significant negative correlation between effect size and results precision ($b_0 = -6.642, SE = 2.238, t = 2.967$, one-tailed $p = .005$; $Tau = -0.366, z = 2.121$, one-tailed $p = .017$). These suggested that smaller or less precise studies tended to report a larger effect size in this meta-analysis. As shown in Figure F, two studies (Jänsch & Hare, 2014; Pareés et al., 2012) had the greatest standard errors and most extreme negative effects. Both studies had effect sizes greater than 2 SD's below mean. After removing Jänsch and Hare (2014) and Pareés et al. (2012), assuming a random-effects model, the mean effect size no longer remained significant ($g = -0.111$ (95%CI: -0.253 to 0.032, $p = .127$), $Q(15) = 14.740, p = .470$).

[Insert Fig. F about here]

Planned subgroup analysis

As suggested by Borenstein et al. (2009), we evaluated diagnostic subgroups that contain at least five effect sizes (i.e. depression). Using a random-effects model, the aggregated effect size for depression did not reach statistical significance ($g = -0.067$, 95%CI: -0.278 to 0.144, $p = .536$). There was no significant heterogeneity within the depression studies ($Q(6) = 0.541, p > .05$).

Respective subgroups for OCD and anxiety disorders contained three studies only. Exploratory analysis showed no significant effect for either group

(OCD: $g = 0.235$, 95%CI: -0.096 to 0.566, $p = .163$; Anxiety disorders: $g = -0.175$, 95%CI: -0.525 to 0.175, $p = .327$).

Discussion

The two meta-analyses synthesised effect sizes of the 'jumping to conclusions' data-gathering bias in healthy individuals as compared with patients with psychotic disorders or delusions (study 1), and with patients with other psychiatric disorders (study 2). The meta-analytic approach increased statistical power and minimised the impact of the potentially non-uniform task paradigms on results. These meta-analyses extended the current literature by including conceptual variants of the beads task, and by examining groups with psychotic and non-psychotic diagnoses. Our main finding was robust evidence for a hastier data-gathering style in patients with psychosis than healthy individuals, with a moderate aggregated effect size. Group differences in data gathering between patients with other psychiatric disorders and healthy individuals were highly heterogeneous, and not significant after removal of extreme outlier data.

Summary of evidence

Consistent with previous reviews (Fine et al., 2007; Garety & Freeman, 2013; Dudley et al., 2014), we found a moderate effect size for the comparison between individuals with psychotic disorders and healthy individuals on data gathering. We reported significant and comparable effect sizes for group selected according to a diagnosis of schizophrenia spectrum disorder, and delusions, all within the moderate range.

It is noteworthy that 18 studies were shared between the two subgroups. In the remaining studies, patients with schizophrenia spectrum disorders might also have delusions even though these were not reported. As a result, the subgroups overlapped considerably and did not represent separate sets of comparisons. Therefore, our sampling strategy did not allow us to examine whether JTC differs in psychotic patients with or without delusions. It would be of interest if effect sizes of the JTC bias on hallucinations only could also be tested, so as to shed light on the question of whether the JTC bias is a phenomenon of psychosis, or whether it is strongly related to delusions alone. However, there are no studies meeting our search criteria of patients with hallucinations only: this would in practice be extremely rare since delusions and hallucinations typically co-occur. The current study leads us to conclude that the JTC bias is consistently evident in psychotic groups with varied symptom profiles.

The second meta-analysis was the first attempt to integrate comparisons of JTC between individuals with non-psychotic disorders and healthy individuals statistically. Dudley et al. (2014) suggested that examination of data gathering in non-psychotic participants would help to address the question whether the JTC style is driven by processes that are more characteristic in specific disorders, e.g. working memory deficit or anxiety. The aggregated effect size for JTC reached statistical significance, indicating a hastier data-gathering tendency in non-psychotic psychiatric groups than healthy individuals. However, the effect sizes varied widely across studies in both directions, leading to highly heterogeneous results. Publication bias tests revealed that studies with the stronger effects had much poorer result precision. Upon careful inspection, there were very extreme

effect sizes contributed by single studies. After removal of these outliers, which resulted in much smaller heterogeneity, the aggregated effect size for data gathering for the remaining studies was no longer significant. It is noteworthy that these two outlier studies were not of patients with diagnoses of common non-psychotic mental disorders but one study of functional movement disorder, and the other of a developmental disorder, Asperger's syndrome.

The greatest precision in the subgroup analysis is likely to be for depression, derived from seven studies and which yielded an effect size close to zero. For OCD and anxiety disorders ($n = 3$ each), there were small and non-significant effect sizes also. Therefore, our data do not at present lend support to the suggestion that JTC is a transdiagnostic phenomenon beyond psychosis.

Although our study did not directly address the question why individuals with psychosis jump to conclusions, it is of note that since most studies either had comparison groups matched on general intelligence or statistically controlled for it, it is not likely that the group effect is attributable to difference in general intelligence.

Limitations

A substantial proportion of studies that fell within our inclusion criteria included a psychotic group, a non-psychotic clinical group, and a healthy control group. Excluding studies that compared two clinical groups with a healthy group would mean exclusion of many clinical studies in this area, rendering the results even less representative. Therefore, we did not exclude the studies that compared the healthy individuals with a psychotic and a non-psychotic group, but separated their effect sizes in two meta-analyses to minimise the impact of statistical interdependence. For the same reason, by reporting only one out of

the multiple comparisons within the same study (e.g. Djamshidian et al., 2012; Lunt et al., 2012; Reese, McNally, & Wilhelm, 2011), our second meta-analysis did not include all effect sizes for all psychiatric disorders available in the literature. With more research that examines data-gathering style across psychiatric disorders and its relationship with specific psychological or neurocognitive processes, the question of whether JTC bias is transdiagnostic can be revisited in the future.

We included the three major data-gathering tasks (the beads task, fish task, and word/survey task). This broadened the scope of studies included compared to other reviews. It is possible that combining findings based on different tasks and paradigms introduced heterogeneity. However, the meta-analyses were sufficiently powered to regulate the impact of heterogeneity by imputing studies. In addition, post hoc subgroup analyses revealed no significant differences in effect sizes between easy (i.e. low ambiguity) and difficult (i.e. high ambiguity) tasks, or between small (i.e. 1-2) and large (i.e. 3-20) number of experimental trials. Therefore, it is not likely that our results are affected systematically by task difficulty or design. By focusing on draws to decision and the dichotomous JTC bias as outcomes only, our study did not incorporate other variables that may be of theoretical importance, such as decision confidence and probabilistic estimates. As there have been recent reports of newer ways to assess data gathering and its subcomponents (e.g. Chu et al., 2015), research may be furthered by comparing JTC results across task paradigms or using computational models (Adams, personal communications).

Conclusions

This set of meta-analyses confirmed that a hasty data gathering style, or the JTC bias, was robust in patients diagnosed with psychotic disorders, whether recruited by diagnosis or by the presence of delusions. On the other hand, effects of JTC in non-psychotic psychiatric disorders were highly heterogeneous, with the overall finding driven by some large effects in single studies of less common disorders, warranting further investigation. On further examination, we found no evidence for JTC in depression. Our current exploratory analyses on OCD and anxiety disorders resulted in small non-significant effect sizes, not suggesting an association.

There are preliminary data that JTC bias predicts antipsychotics-induced improvement in delusions (So et al., 2014) and psychotic symptoms (Menon et al., 2008). Dudley et al (2013) also found that patients who improved in JTC over two years had a better clinical outcome than those whose JTC bias was unchanged over time. These findings indicating that JTC predicts outcomes, together with accumulating support for the efficacy of new treatment approaches targeting JTC (Garety et al., 2015; Moritz et al., 2014; So et al., 2015; Waller et al., 2015), we conclude that the development of process-based interventions for JTC may show promise in enhancing treatment responses in patients with psychosis.

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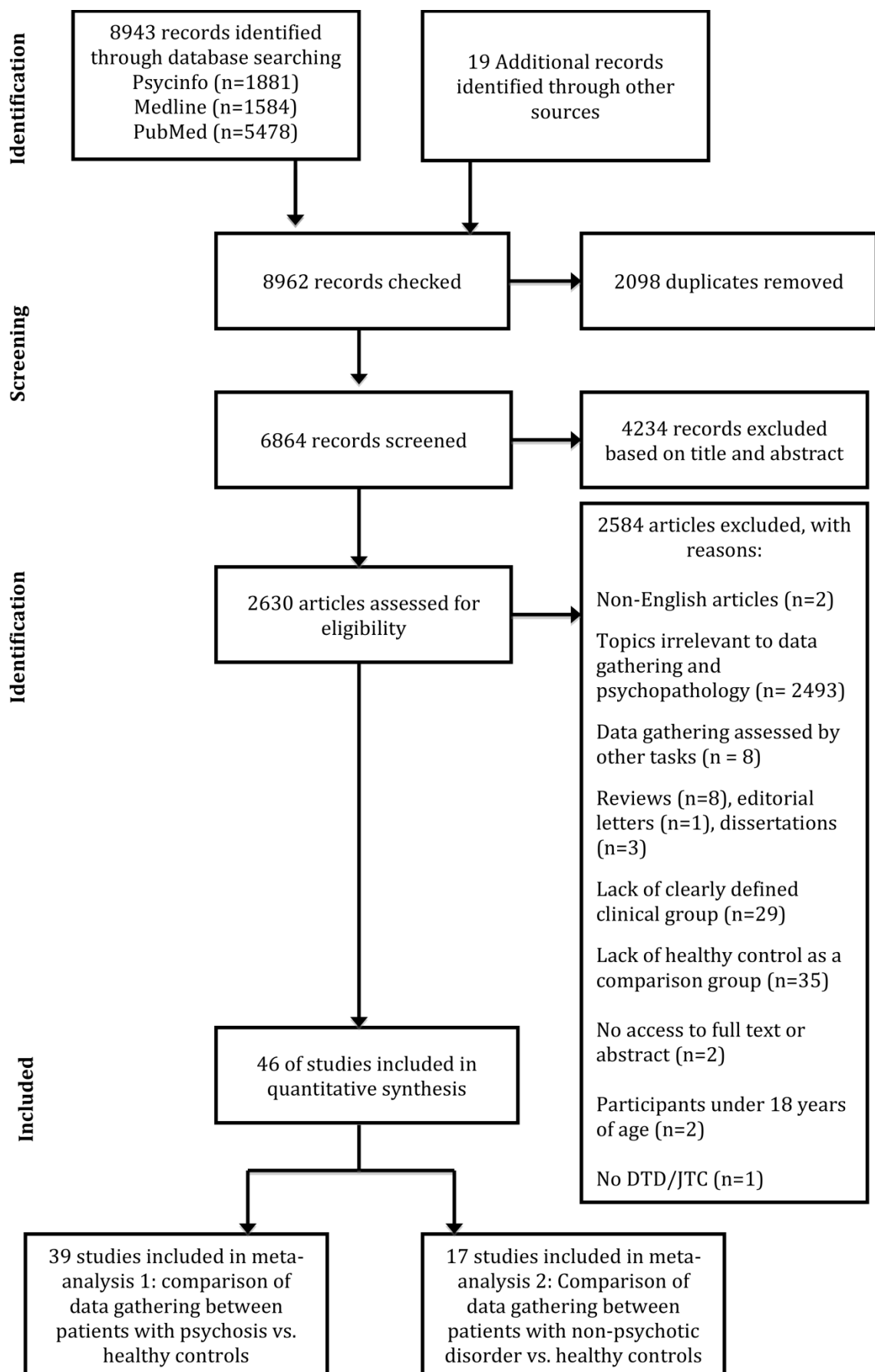


Fig. A. Flow chart of the two meta-analyses.

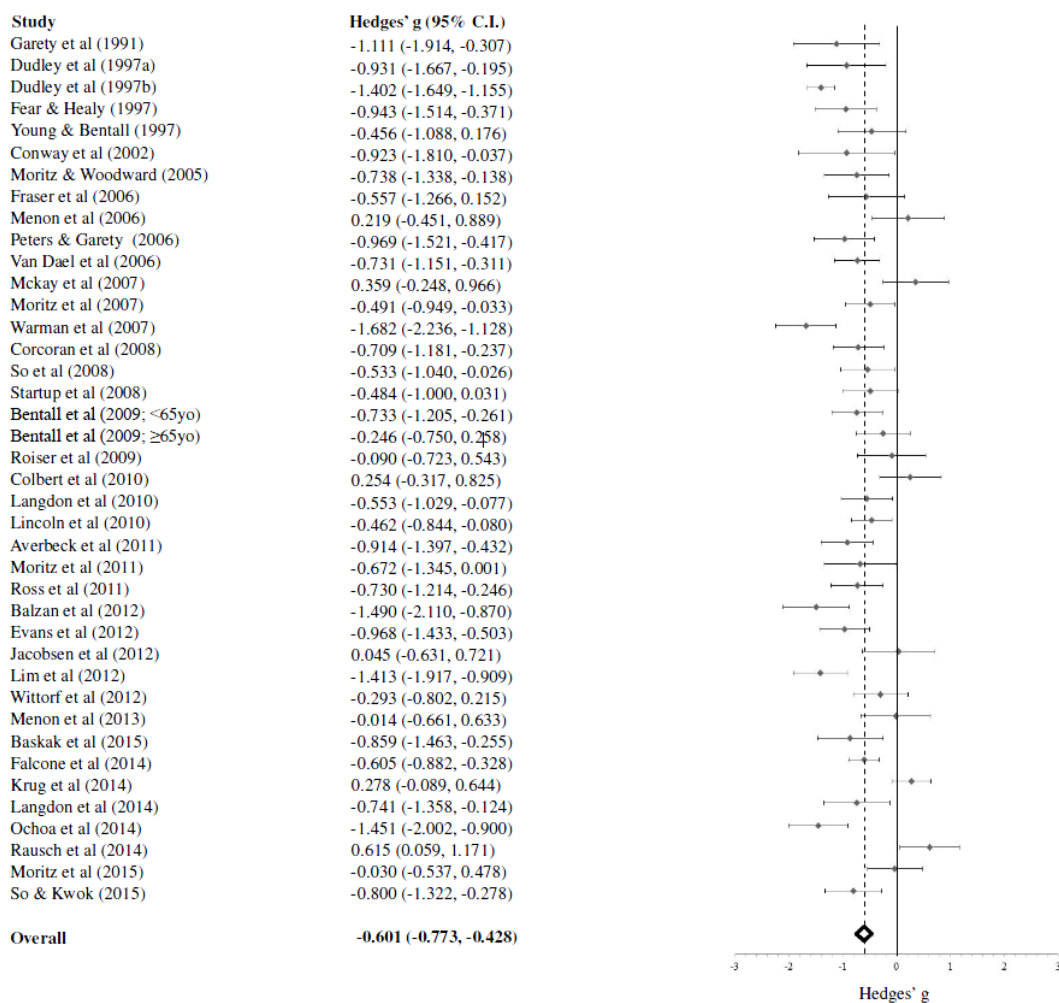


Fig. B. Forest plot of JTC in psychotic disorders.

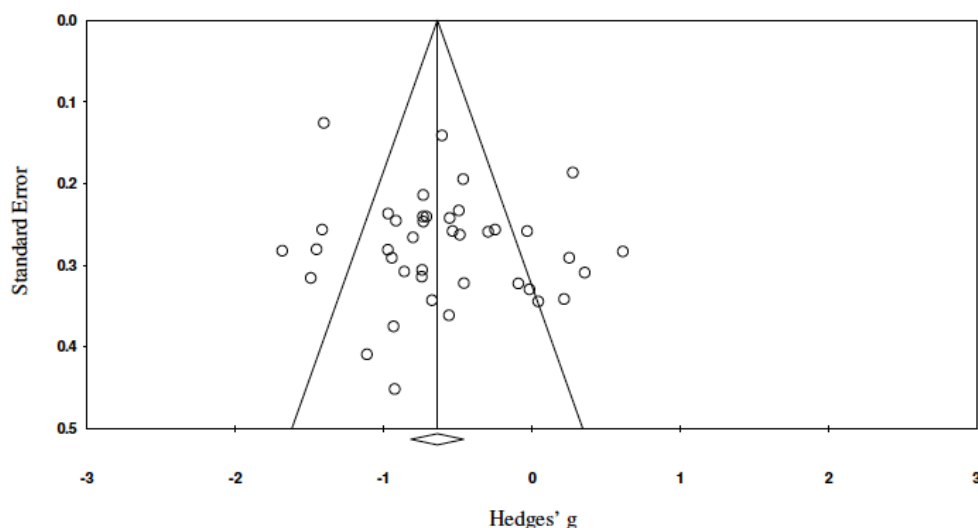


Fig. C. Funnel plot of standard error by Hedges' g for studies of psychotic disorders.

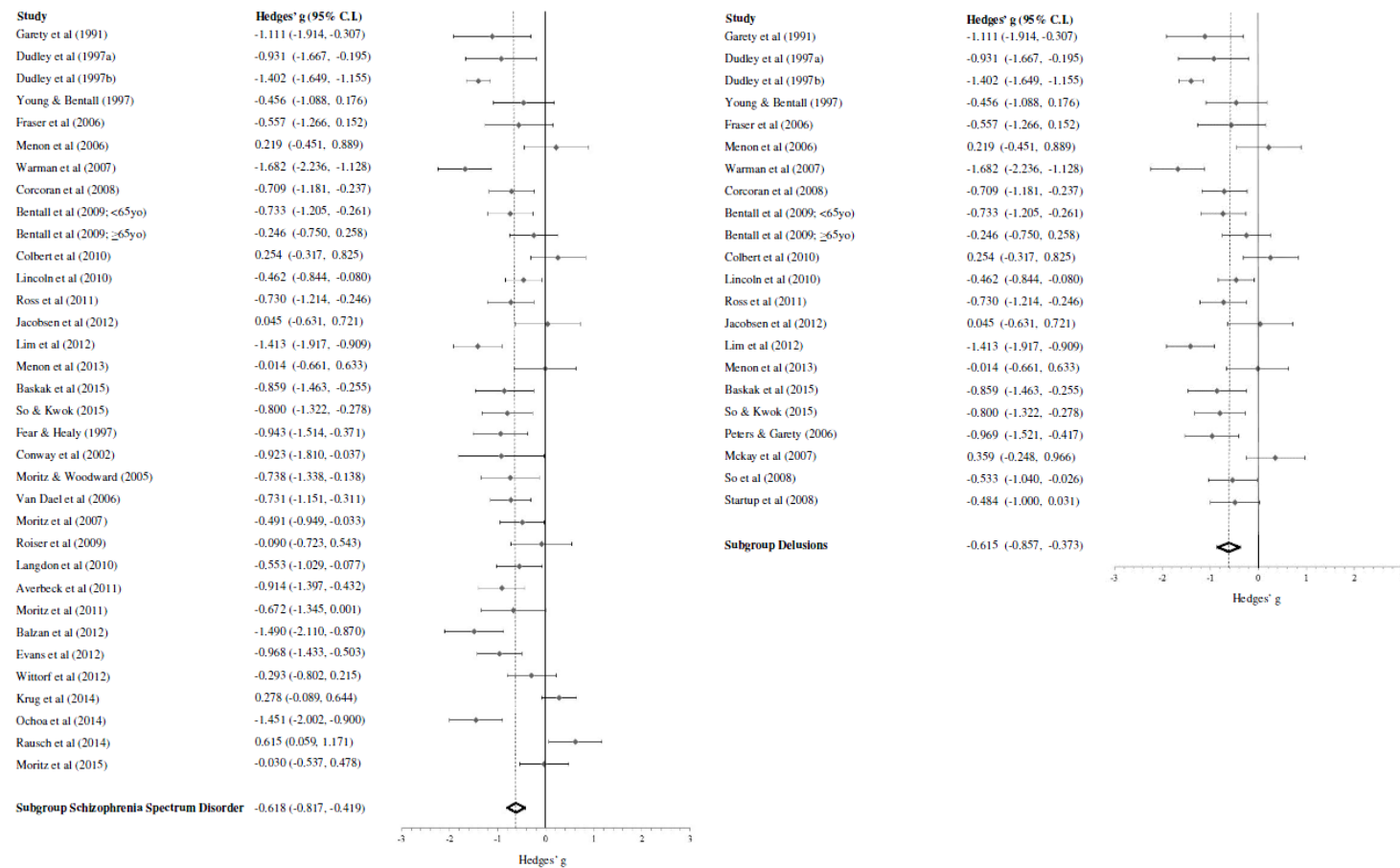


Fig. D.1-2. Subgroup analyses of JTC in schizophrenia spectrum disorders (left) and in delusions (right).

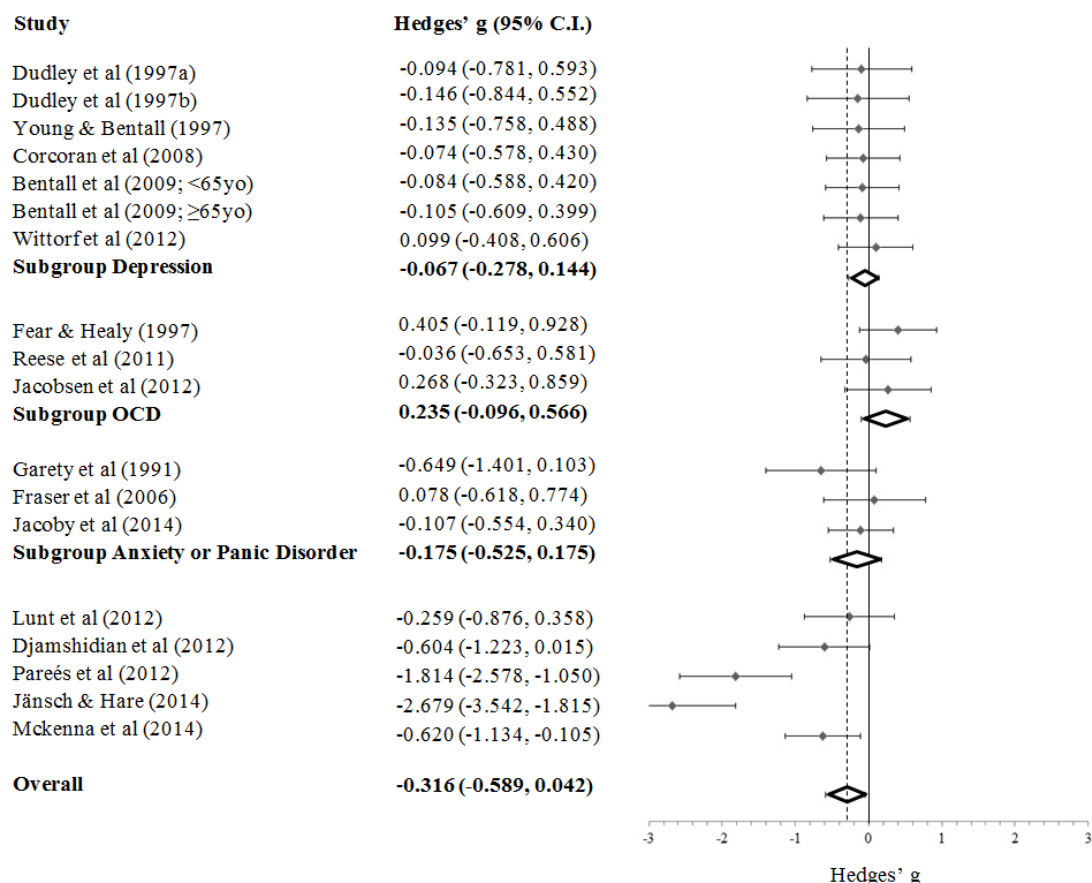


Fig. E. Forest plot of JTC in non-psychotic psychiatric disorders.

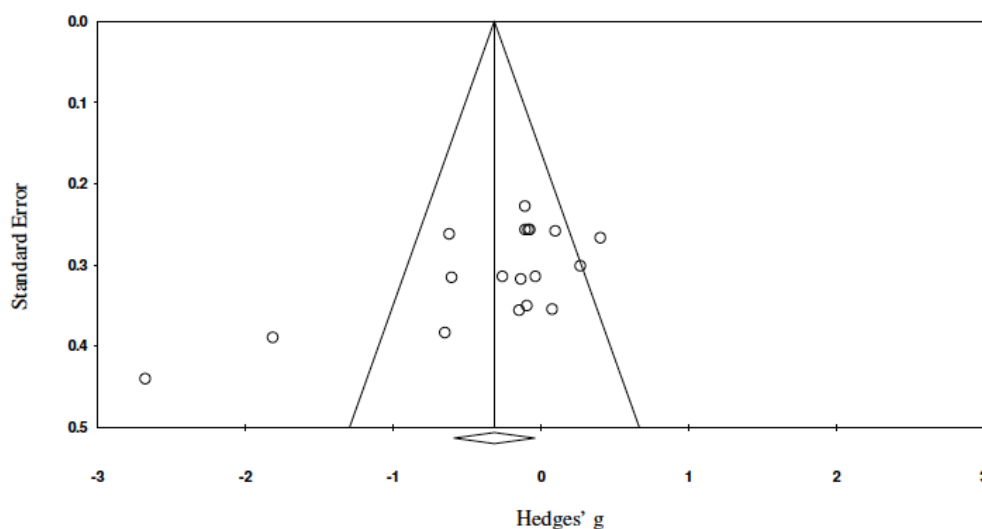


Fig. F. Funnel plot of standard error by Hedges' g for studies of non-psychotic psychiatric disorders.

Appendix A - Study characteristics 20160309.

Studies included in both meta-analyses 1 and 2 (N=10)									
Study	Clinical sample for analysis	Control sample for analysis	Design	Diagnostic tool	JTC task	Task paradigm	JTC measure	Risks of bias	
Wittorf et al (2012)	Schizophrenia (N=20) Anorexia nervosa (N=15)	N=55	Cross-sectional	SCID-I	Fish task (80:20)	Terminate upon decision	DTD JTC	Selection: Performance: Detection: Attrition: Reporting:	Good Good Good Good Good
Bentall et al (2009)	Schizophrenia/ schizoaffective disorder with delusions; <65yo (N=39), ≥65yo (N=29) Depression: <65yo (N=27), ≥65yo (N=29)	<65yo (N=33) ≥65yo (N=31)	Cross-sectional	SCAN, MMSE	Beads task (60:40) Survey task (60:40)	Terminate upon decision	DTD	Selection: Performance: Detection: Attrition: Reporting:	Good Good Good Good Good
Fear & Healy (1997)	Delusional disorder (N=22) OCD (N=26)	N=30	Cross-sectional	DSM-III-R	Beads task (85:15)	Terminate upon decision	DTD JTC	Selection: Performance: Detection: Attrition: Reporting:	Good Good Good Good Good
Young & Bentall (1997)	Schizophrenia or delusional disorder with delusions (N=19) Depression (N=13)	N=19	Cross Sectional	DSM-III-R	Beads task (60:40; 75:25; 85:15; 90:10)	Graded estimate	DTD (draws to certainty rating of 2)	Selection: Performance: Detection: Attrition: Reporting:	Good Good Good Good Good
Corcoran et al (2008)	Schizophrenia spectrum disorder with delusions (N=39)	N=33	Cross Sectional	SCAN (DSM-IV)	Beads task (60:40) Word task	Terminate upon decision	DTD	Selection: Performance: Detection:	Good Good ?

	Depression (N=27)				(60:40)			Attrition: Good Reporting: Good
Dudley et al (1997a)	Schizophrenia with delusions (N=15) Depression (N=15)	N=15	Cross sectional	DSM-III-R	Beads task (85:15; 60:40)	Terminate upon decision	DTD	Selection: Fair Performance: Good Detection: Good Attrition: Good Reporting: Good
Dudley et al (1997b)	Schizophrenia with delusions (N=15) Depression (N=16)	N=15	Cross sectional	DSM-IV	Name task (60:40) Survey task (60:40)	Terminate upon decision	DTD	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Jacobsen et al (2012)	Schizophrenia spectrum disorder with delusions (N=16) OCD (N=32)	N=16	Cross Sectional	SCID-I	Beads task (85:15; 60:40) Survey task^	Terminate upon decision	DTD	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Fraser et al (2006)	Schizophrenia spectrum disorder with delusions (N=15) Panic disorder (N=15)	N=15	Cross Sectional	SCID (DSM-IV)	Word task (60:40) Survey task (60:40)	Terminate upon decision	DTD	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Garety et al (1991)	Schizophrenia with delusions (N=13) Anxiety disorder (N=14)	N=13	Experimental	DSM-III & RDC	Beads task (85:15)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Other studies included in meta-analysis 1 only (N=29)								
Study	Clinical sample for analysis	Control sample for	Design	Diagnostic tool	JTC task	Task paradigm	JTC measure	Risks of bias

		analysis						
Moritz & Woodward (2005)	Schizophrenia (N=31)	N=17	Cross-sectional	DSM-IV	Beads task (90:10)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Peters & Garety (2006)	Delusions (N=22)	N=36	Repeated measures	Manchester Scale	Beads task (85:15; 50:50)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: ? Attrition: Good Reporting: Good
Conway et al (2002)	Delusional disorder (N=10)	N=10	Cross-sectional	DSM-IV	Beads task (85:15)	Terminate upon decision	DTD	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Menon et al (2006)	Schizophrenia with delusions (N=18)	N=18	Cross sectional	RDC	Beads task (85:15; 60:40) Survey task (60:40)	Terminate upon decision	DTD	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Moritz et al (2007)	Schizophrenia (N=37)	N=37	Cross-sectional	MINI, DSM-IV	Beads task (90:10)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Fair Reporting: Good
Startup et al (2008)	Delusions (N=28)	N=30	Cross-sectional	PSE-10	Beads task (60:40)	Terminate upon decision	DTD JTC	Selection: Fair Performance: Good Detection: Good Attrition: Good Reporting: Good

So et al (2008)	FEP with delusions (N=30)	N=30	Cross-sectional	ICD-10	Beads task (85:15; 60:40)	Terminate upon decision	DTD JTC	Selection: Fair Performance: Good Detection: Good Attrition: Good Reporting: Good
Lincoln et al (2010)	Schizophrenia spectrum disorder with delusions (N=44)	N=68	Cross-sectional	DSM-IV	Beads task (80:20; 60:40)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Colbert et al (2010)	Schizophrenia spectrum disorder with delusions (N=17)	N=35	Cross sectional	ICD-10	Beads task (85:15; 60:40)	Terminate upon decision	DTD JTC	Selection: Fair Performance: Good Detection: Good Attrition: Good Reporting: Good
Roiser et al (2009)	Schizophrenia/schizoaffective disorder (N=20)	N=17	Longitudinal	DSM-IV WHO Psychosis Screen	Beads task (60:40)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Menon et al (2013)	Schizophrenia/schizoaffective disorder with delusions (N=18)	N=17	Cross Sectional	MINI/ Based on DSM-IV	Beads task (60:40) Survey task (60:40)	Terminate upon decision	DTD	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Ross et al (2011)	Schizophrenia spectrum disorder with delusions (N=34)	N=34	Experimental	Case notes	Beads task (85:15; 60:40)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Falcone et	FEP (N=108)	N=101	Cross	OPCRIT/	Beads	Terminate	DTD	Selection: Good

al (2014)			sectional	DSM-IV	task (85:15; 60:40)	upon decision	JTC	Performance: Good Detection: Good Attrition: Good Reporting: Good
Langdon et al (2014)	FEP (N=23)	N=19	Cross sectional	DIP (based on ICD-10) SCID-I/DSM-IV	Beads task (85:15)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Evans et al (2012)	Schizophrenia (N=39)	N=39	Case-control	DSM-IV	Beads task (85:15)	Terminate upon decision	DTD	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Langdon et al (2010)	Schizophrenia / schizoaffective disorder (N=35)	N=34	Cross-sectional	DSM-IV DIP	Beads task (85:15)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Moritz et al (2011)	Schizophrenia/ schizoaffective disorder (N=20)	N=15	Randomized repeated measures	MINI	Fish task (80:20)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Warman et al (2007)	Schizophrenia/ schizoaffective disorder with delusions (N=37)	N=30	Cross-sectional	SCID	Beads task (60:40)	Terminate upon decision	DTD	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
McKay et al (2007)	Persecutory delusion (N=22)	N=19	Cross-sectional	DSM-IV	Beads task (85:15)	Terminate upon	DTD JTC	Selection: Good Performance: Good

						Decision		Detection: Good Attrition: Good Reporting: Good
Krug et al (2014)	Schizophrenia spectrum disorder (N=57)	N=57	Cross-sectional	SCID-I	Beads task (60:40)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Lim et al (2012)	Schizophrenia spectrum disorder with delusions (N=25)	N=40	Cross-sectional	DSM-IV-TR	Beads task (85:15; 60:40) Survey task (85:15; 60:40)	Terminate upon Decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Ochoa et al (2014)	Schizophrenia (N=29)	N=34	Cross-sectional	DSM-IV-R	Beads task (85:15; 60:40) Survey task (60:40)	Terminate upon Decision	JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Baskak et al (2015)	Schizophrenia/schizoaffective disorder with delusions (N=25)	N=20	Cross-sectional	DSM-IV	Beads task (90:10, 55:45)	Terminate upon Decision	DTD	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Averbeck et al (2011)	Schizophrenia (N=33)	N=39	Cross-sectional	DSM-IV	Beads task (85:15)	Terminate upon Decision	DTD	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Van Dael et al	Schizophrenia spectrum disorder (N=40)	N=53	Cross-sectional	RDC	Beads task (85:15)	Terminate upon	DTD JTC	Selection: Good Performance: Good

(2006)						Decision		Detection: Good Attrition: Good Reporting: Good
Rausch et al (2014)	Schizophrenia (N=23)	N=28	Cross-sectional	DSM-IV-R	Fish task (80:20)	Graded estimate	DTD	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
So & Kwok (2015)	Schizophrenia spectrum disorder with delusions (N=28)	N=32	Cross-sectional	Casenotes	Beads task (85:15; 60:40)	Terminate upon Decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Balzan et al (2012)	Schizophrenia (N=25)	N=25	Cross-sectional	PDI-21	Beads task (90:10)	Graded estimate	JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Moritz et al (2015)	Schizophrenia or schizoaffective disorder (N=30)	N=29	Experimental	MINI	Fish task (60:40; 85:15)	Graded estimate	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Other studies included in meta-analysis 2 only (N=7)								
Study	Clinical sample for analysis	Control sample for analysis	Design	Diagnostic tool	JTC task	Task paradigm	JTC measure	Risks of bias
Djamshidian et al (2012)	Pathological gamblers (N=23)	N=18	Cross sectional	MMSE DSM-IV	Beads task (80:20; 60:40)	Terminate upon decision	DTD	Selection: Good Performance: Good Detection: Good

								Attrition: Good Reporting: Good
Jacoby et al (2014)	Anxiety disorder (N=69)	N=26	Cross sectional	MINI DSM-IV:	Beads task (85:15; 60:40; 44:28:28)	Terminate upon decision	DTD	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Lunt et al (2012)	ADHD (N=20)	N=19	Cross sectional	DSM-IV	Beads task (85:15; 60:40)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
McKenna et al (2014)	Anorexia nervosa (N=27)	N=33	Cross sectional	Case notes DSM-IV	Beads task (60:40)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Parees et al (2012)	Functional Movement Disorder (N=18)	N=18	Cross sectional	Fahn & William's criteria (1988)	Beads task (85:15)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Jansch & Hare (2014)	Asperger syndrome (N=30)	N=30	Cross sectional	DSM-IV ICD-10	Beads task (85:15; 60:40)	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good Reporting: Good
Reese et al (2011)	OCD (N=20)	N=20	Cross Sectional	SCID (DSM-IV)	Beads task (85:15; 60:40) Survey task	Terminate upon decision	DTD JTC	Selection: Good Performance: Good Detection: Good Attrition: Good

					(85:15; 60:40)			Reporting: Good
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Appendix B – AHRQ risk of bias criteria

General instructions: Rate each criterion as 'Good' (low risk of bias), 'Fair', 'Poor' (high risk of bias), or '?' (if there is no information to base judgment on). Factors to consider when rating each criterion are listed below.

1. Selection bias

- clear description of recruitment strategy
- clear description of inclusion and exclusion criteria
- comprehensive description of sample demographics
- comparability of groups at baseline in terms of baseline characteristics
- representativeness of sample
- absence of confounds
- adjustment of confounds in analysis (especially for intellectual functioning or years of education which may be related to task performance)
- validated method for ascertaining psychiatric disorders and delusionality (use of formal diagnostic interviews and symptom rating scales)
- validated screening procedure for healthy individuals

2. Performance bias

- detailed and clear description of the assessment paradigm for data gathering, i.e. name of task, choice of task material, ratio of stimuli presented, details of task paradigm, number of trials conducted
- appropriate choice of data-gathering task
- complete reporting of behavioural measures of data gathering

3. Detection bias

- fidelity of the assessment procedure, e.g. consistent testing procedure used across groups, use of computerized tasks
- unbiased and correct assessment of outcome, e.g. blinding of assessors

4. Attrition bias

- completeness of data
- lack of difference between participants with missing values and completers
- appropriate handling of missing values

5. Reporting bias

- publication biases
- conflict of interests
- selective reporting of results (e.g. only significant results were published)

Appendix C. References solely included in meta-analyses 1 and 2.

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Highlights

- Forty six studies on jumping-to-conclusions bias were included in two meta-analyses
- Patients with psychosis had a hastier data-gathering style than healthy controls
- JTC is consistently evident in psychotic groups with varied symptom profiles
- JTC was not evident in non-psychotic psychiatric disorders after removing outliers
- No significant effect of JTC was found in depression